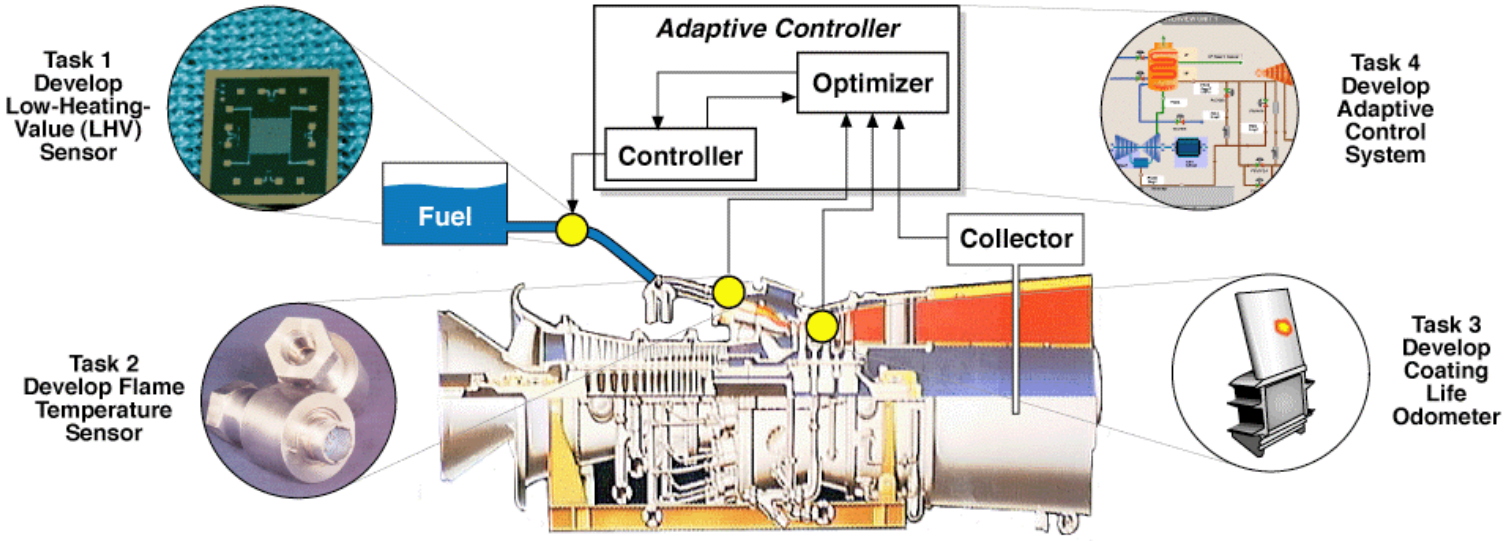
Smart Power Turbine Project

DOE-NETL Cooperative Agreement DE-FC26-01NT41021

Technologies for DOE Smart Power Turbine:



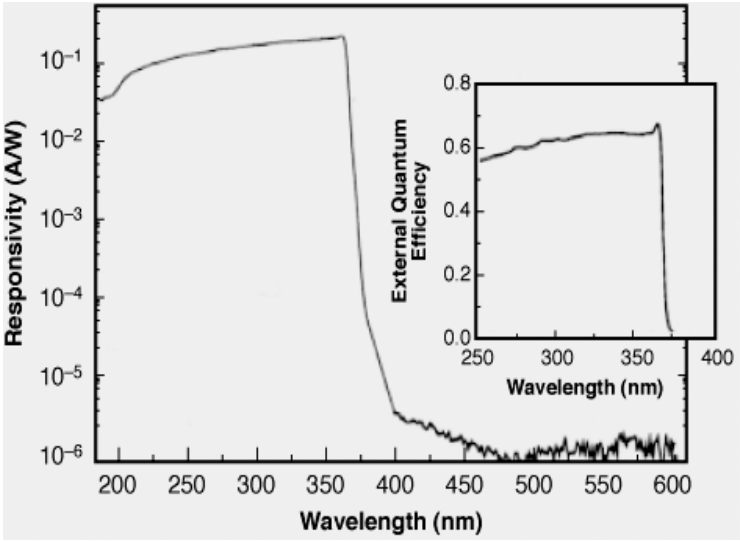
Project Objectives:

- Fuel LHV measurement – strategic partner Sandia National Laboratory.
- Flame temperature sensor - GE High bandgap semiconductor photodiode
- Coating life odometer - Taggants which detect incipient coating loss
- Adaptive supervisory control / optimizer

2 year, 2.2 Million dollar program
GE Power Systems, GE Research Center, and Sandia NL

Smart Power Turbine: Flame Temperature Sensor

- Build on success of existing SiC flame detector.
- Existing sensor detects flame **on** or **off**.
- Dual photodiode with wavelength discrimination for temperature measurement.



Tune detector response to specific wavelengths of interest

Direct flame temperature measurement in combustor.

Multi-wavelength calibration can compensate for window loss!!

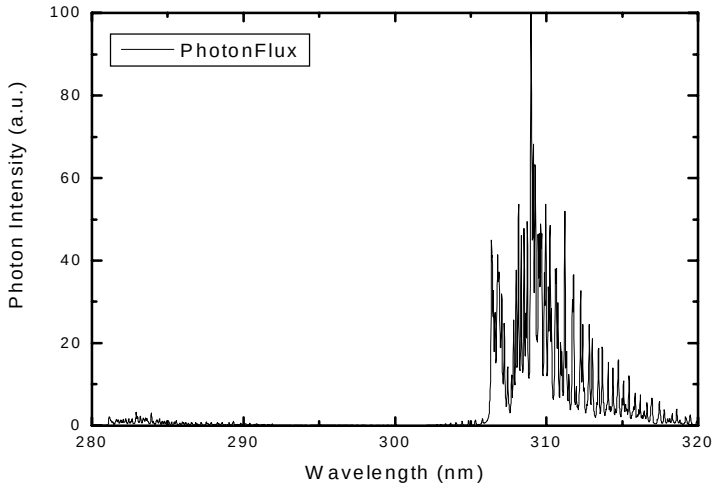
Breadboard test cell runs ongoing.

Theoretical – Analysis

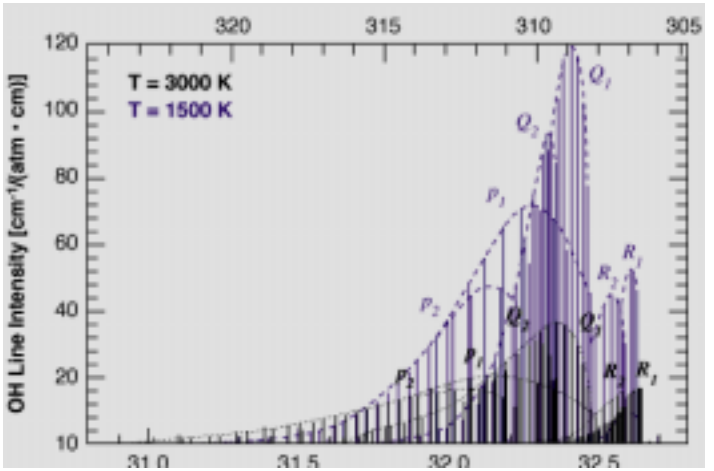
Approach

- The various molecular emission spectra can be simulated as a function of pressure, temperature and wavelength to match a range of conditions.
- No significant difference in emission flux is observed as a function of widely varying pressures (1 to 20 atms).
- This output was used for a prediction of the detector ratios over the temperature range of interest.

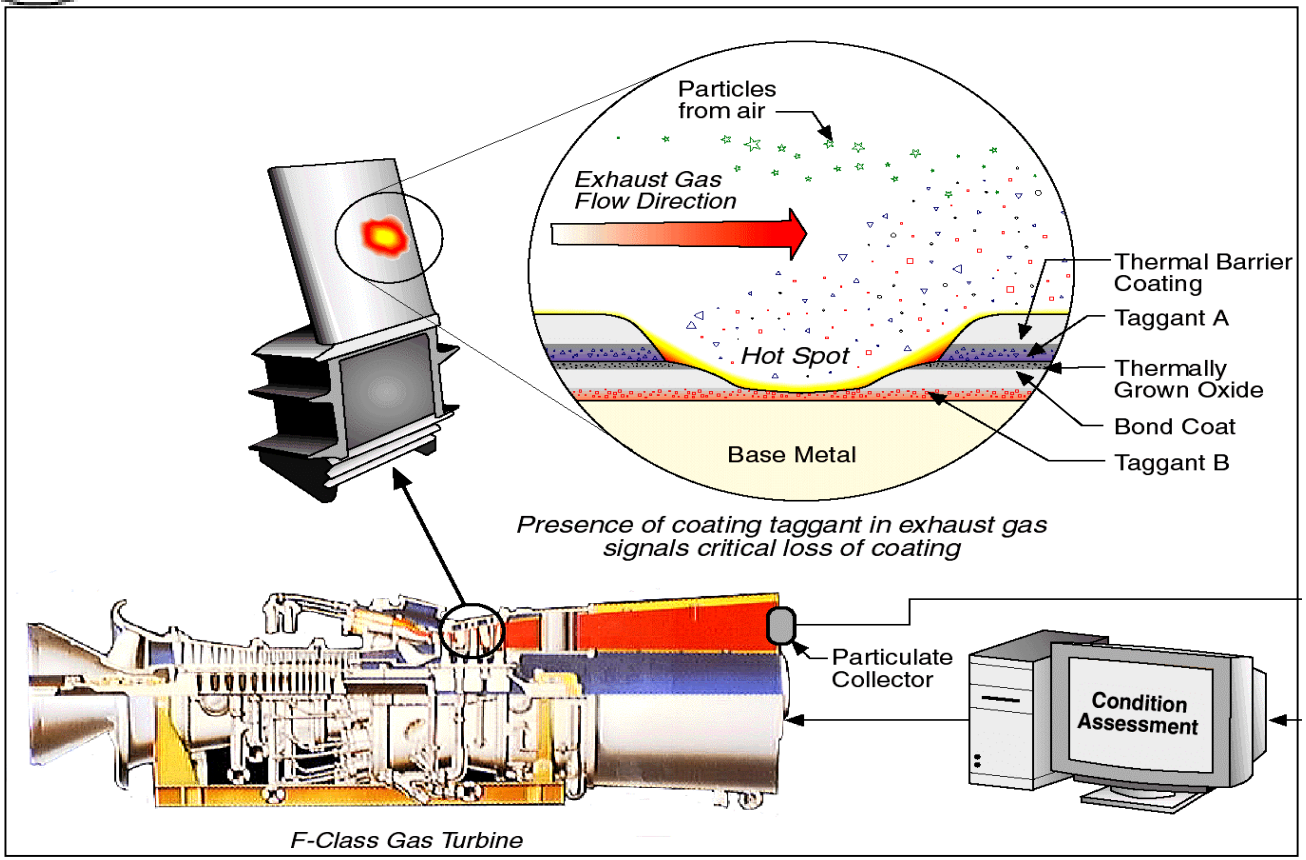
OH emission spectra



Temperature causes shift in wavelength of gas emissions.



Smart Power Turbine: Coating Taggant system



Online detection scheme

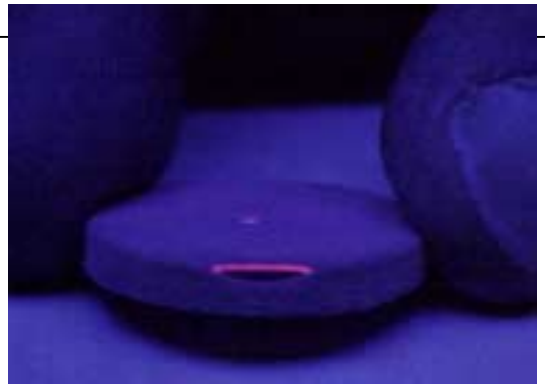
Buried taggants in coatings will be detected by exhaust collection system after spallation event.

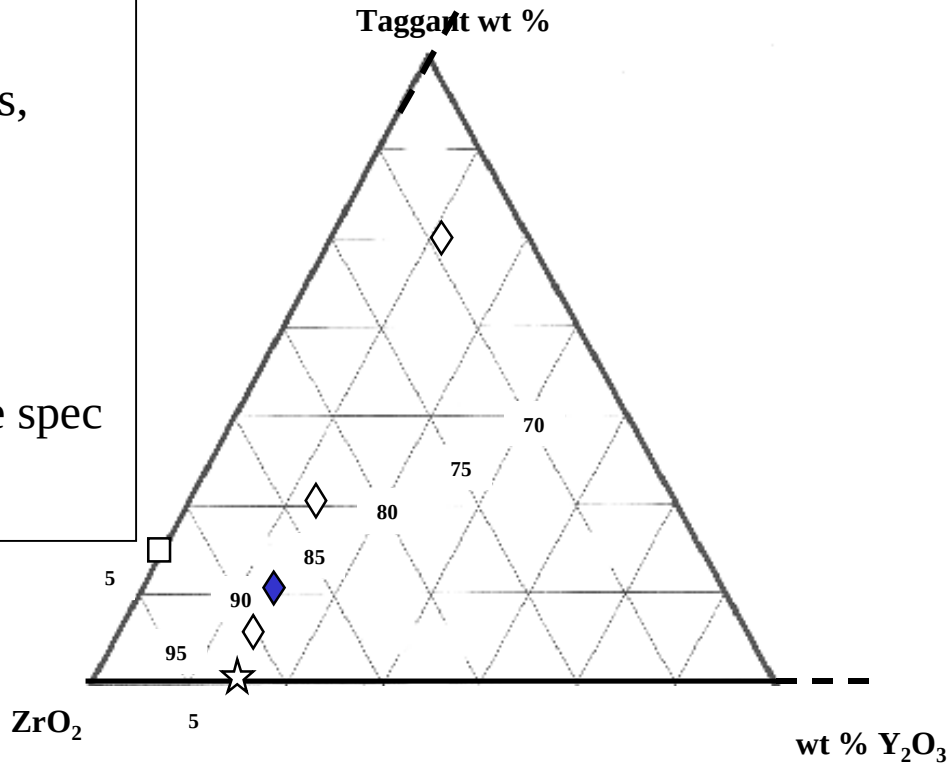
Rare earth materials chosen for low background signal and compatibility with TBC:

- **Ceria** CeO_2
- **Dysprosia** Dy_2O_3
- **Hafnia** HfO_2,
- **Europia** Eu_2O_3

Designed Experiment on taggant composition

- Screening of effect of taggant- composition on properties
  - 2.5 wt%, 5 wt %, 10 wt %, 25 wt % in 8YSZ
  - 8 wt% in Zirconia
  - Property evaluation - Tensile, modulus, FCT, fluorescence and phase stability
- Thermal stability
  - Baseline against 8YSZ
  - Temperatures: 1000, 1200, 1400 °C
  - Need a good mechanical test to set the spec limit on destabilization

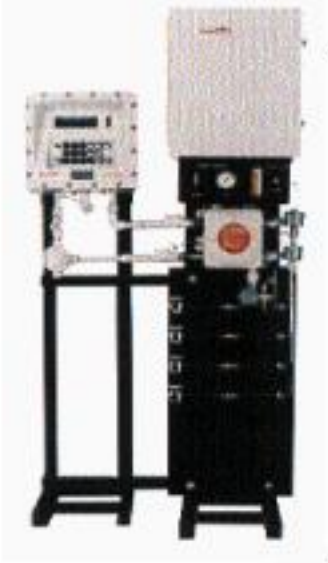




Smart Power Turbine: Fuel LHV sensor

Fuel quality is an increasingly significant problem

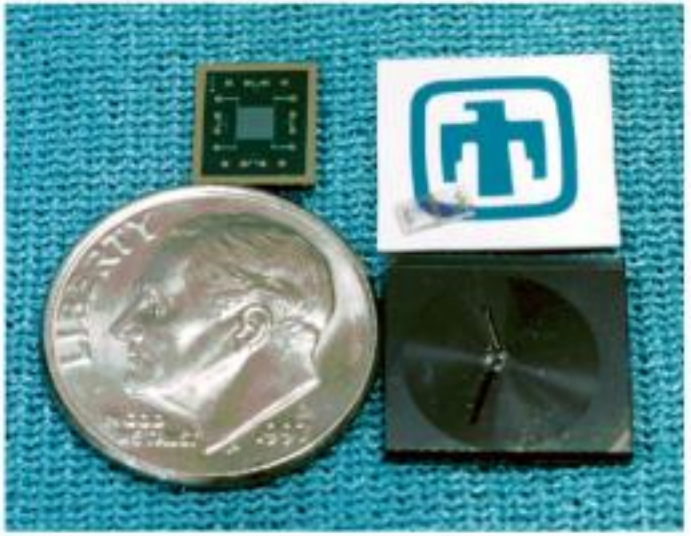
Commercial SOA

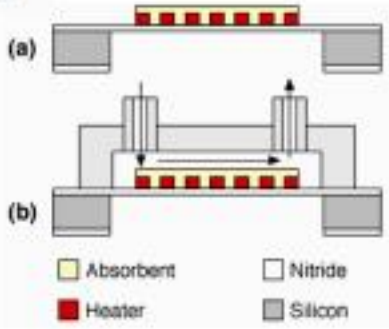


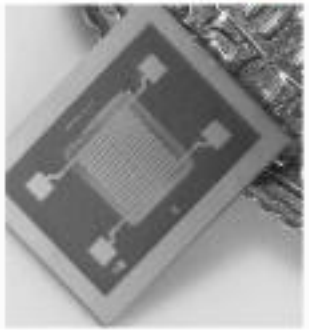
- ~10 minutes response
- calculated LHV

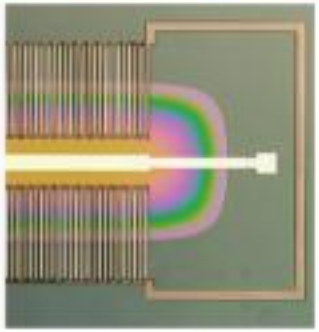
- millisecond response
- direct calorimetric LHV
- distinguished by constituents

Sandia Labs MEMS technology







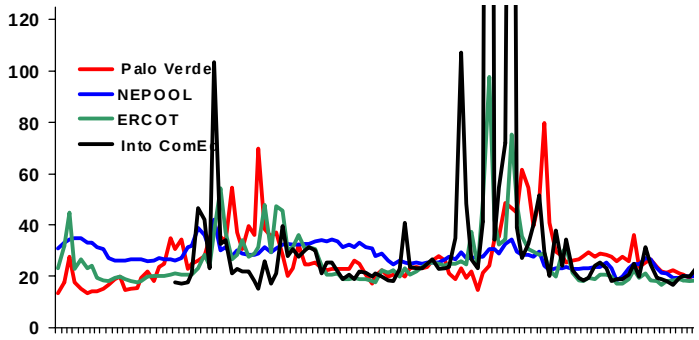


The "missing link" for accurate plant efficiency assessment.

Smart Power Turbine: Adaptive Supervisory Control

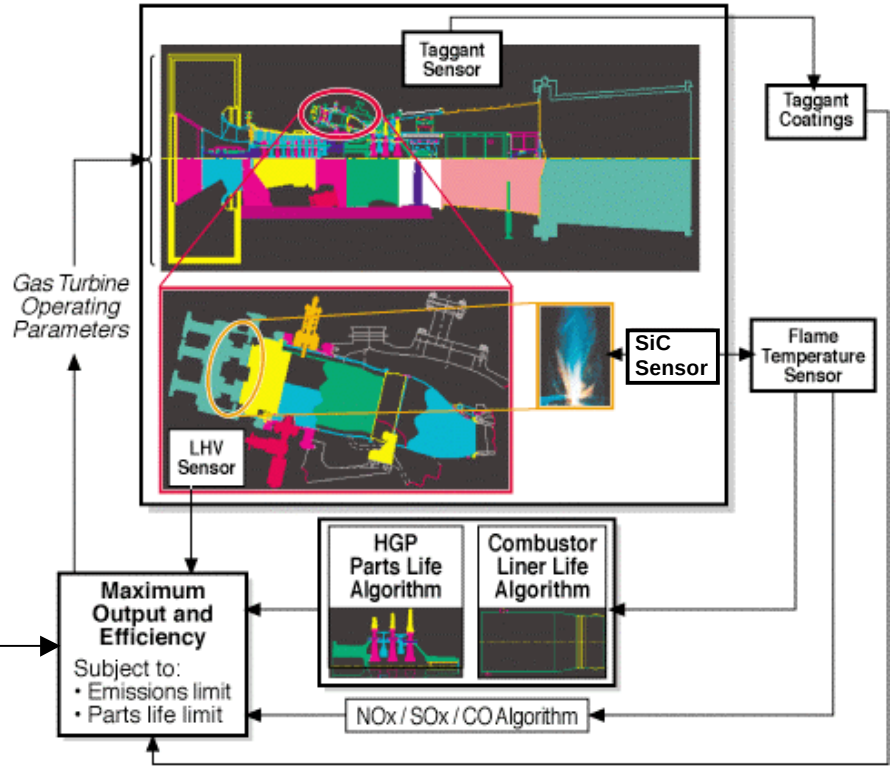
- **Supervisory Control provides input to base controller in real time.**

- **Input sensor data dictates real time limit on T fire subject to NOX and other constraints.**



Real time Electric/Fuel price

Optimizing Algorithm



Utilize developmental sensor data and optimizing routines along with parts life and electric/fuel pricing data to maximize operational profitability of power plant.

Smart Power Turbine Project

System Integration and Testout

- Have had several runs in the atm rig for the FTS.
- Gearing up for a combined run in Cell 5 for March.
- Testing taggants online detection and FTS.

Control Room and
Single Combustor Rig